

## NOTES ON THE GEOLOGY OF BOWNING, N.S.W.

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(Plate XXI.)

The following notes bear more particular reference to the Geology of the Parish of Bowning, and a small area eastward of it bounded by Limestone Creek. Some general references will also be made to the geological features of the country to the west of this area.

The former area may for convenience be considered as consisting of two divisions, one extending in an east and west direction from Limestone Creek to a low ridge or boss of quartz porphyry about a mile west of the Public School on the Great Southern Road, and running in a generally N. and S. course, parallel with the strike of the sedimentary rocks; the other extending from this ridge westward to the Black Range, or western boundary of the parish.

*Physical Features.*—The Parish of Bowning forms a small portion of the Southern Table Lands, and has an elevation above the sea of from 1,800 ft. to 2,400 ft. The surface is of an undulating character in the central and northern area, and decidedly rugged in the southern.

The most striking feature is Bowning Hill, which is a pyramid-shaped mass rising abruptly to a height of from 600 to 700 ft. above the immediate level on the eastern boundary line of the parish.

The principal valley forms the basin of Bowning Creek, and follows the general strike of the rocks, having been formed chiefly by the erosion of the exposed edges of the more fragile kinds.

The porphyry ridge already referred to divides the parish into two fairly equal parts, and separates the waters of Bowning and

Two-mile Creeks in the higher portions of their basins. Ultimately the Two-mile Creek crosses a denuded part of the ridge, and joins the Bowning Creek two miles south of the township. From this until it joins the Yass River, the bed of the Bowning Creek chiefly passes along quartz porphyry, and, notwithstanding the insignificance of the stream and the extreme hardness of the rock, it has, for some miles, worn a passage of considerable depth.

*Climate.*—The climate of Bowning may be termed cool. For eight months of the year frosts are common, and usually during each winter light falls of snow take place. Even in winter when the sky is cloudless the days are genial; but with sunset the temperature rapidly falls in winter and summer alike. In summer the temperature rarely exceeds 100° F. in the shade, and occasionally frosts occur in December. These extremes of temperature are trying to delicate constitutions.

The average rainfall is about 20 inches per annum. The prevailing winds are westerly. During the month of November they blow west from sun-rise to sun-set, when an east wind succeeds, that is, a sea breeze, which lulls towards midnight.

In December and January when the Great Plains of the west have been thoroughly heated, it is not unusual for the wind to set eastward for three or four days continuously.

The easterly winds bring up the rain-clouds; but the moisture is not precipitated until their return by the westerly winds, except at rare intervals.

*Distribution of Rocks.*—In the eastern division of the area now treated of, and starting from the eastern boundary, is a bed of coralline limestone, a continuation of the same bed concerning which Mr. Jenkins has already given some interesting details in his paper 'On the Geology of Yass Plains.' (1) Next succeeds a stratum of shale with masses of coral distributed through it, then fossiliferous shale, and an impure limestone, the 'trilobite-

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(1) Proc. Linn. Soc. N.S.W. Vol. III. pp. 21, 216; Vol. IV. p. 404.

bed' of Mr. Jenkins. Then follows an immense bed of shale or mudstone which readily crumbles to mould when exposed to the action of the sun and air.

From Barber's Creek to Bowning Creek the Great Southern Railway crosses the bed almost at right angles with the strike for a distance of three miles, and exposes it in all the cuttings. On the rises to the N. and S. of the railway, bands of flagstone varying from an inch to two or three feet in thickness occur. They are in general separated by layers of mudstone or micaceous slightly coherent grit. Almost encompassing the mass forming Bowning and Bald Hills and stretching out from it on the east to Barber's or Derringullen Creek, is a bed of coarse conglomerate. In places this bed has undergone much alteration, and presents a porphyritic appearance, the enclosed pieces of coral having been silicified. In others the change has been slight, and corals enclosed remain perfect. Bowning Hill and contiguous mass is composed of metamorphic rock, the base being in my opinion quartz porphyry, and the superincumbent portion a porphyroid or felstone. In the vicinity of Bowning township the rocks found to the east, with the exception of the limestone, recur. In the position that the limestone should occupy, did it occur on the western side of this division, is a thick bed of coarse silicious grit intercalated with strata of fine, friable, micaceous sandstone, and altered shales. Immediately east of this grit is a thin bed of sinter-like rock, evidently originally a coralline limestone. Also in conjunction with this grit occur thin beds of quartzites and jasper. One of these quartzite beds I shall designate the *Atrypa* Zone, because of the vast number of *A. reticularis* contained in it. And lastly advancing westward is the quartz porphyry ridge. This extends W. to the Two-mile Creek, and on the Great Southern Road has a thickness of about 5,000 ft. Where it has been much denuded the interior shows a very granitic aspect; and some fragments of it that I submitted to the Mines Department were determined to be granite. But this determination was arrived at from macroscopical inspection only, and therefore cannot be accepted as conclusive. South of Bowning Hill between Bowning and

Derringullen Creeks to the Yass River, the following rocks appear in the order named—conglomerates, shales, impure limestones, limestone, incoherent micaceous sandstone, coarse sandstones and flagstones, and porphyry.

In the western division, starting from the porphyry ridge and proceeding from east to west, first appears a bed of fossiliferous shale, the decomposition of which has formed a fertile loamy soil. Beyond this, as seen on the Binalong Road, are some veins of jasper, and a bed of sandstone containing minute fossils. West of these rocks to the boundary of the Parish at Flinter's Gap on G. S. Road, all the rocks exposed appear more or less altered, though undoubtedly of sedimentary origin. A large proportion of them are cherty in character, and some are porphyritic.

At Murray's Hill and along the N. W. boundary of the parish porphyry intrudes. The southern part of this division I have not had the opportunity of examining fully; but from a casual inspection the rocks seem less altered, and sandstones occur in several places. About three miles S.W. of the township a remarkable felsitic grit is exposed shewing some fossils. Through this grit E. and W. runs a diorite dyke, the grit on each side of it merging gradually into the diorite. Through the diorite runs a quartz vein bearing a good percentage of copper and galena with a little silver. In this place also is a small outcrop of limestone in which a few fossils are imbedded. It is worthy of remark here that the same limestone is visible in the Two-mile Creek about a mile to the east, and on the opposite side of the porphyry ridge, thus showing that the porphyry is intrusive.

*Position of the stratified rocks.*—The stratified rocks have all undergone change from their original position, and are considerably tilted and folded, but maintain throughout conformability, as well as a regular strike and dip.

The general strike is a little E. of N., and the dip N. of W. The dip varies from  $5^{\circ}$  to as much as  $87^{\circ}$ . The eastern division forms a synclinal basin, having been tilted on the W. side by the

intrusion of the porphyry boss, and synchronously on the E. by a similar intrusion. Among the results effected by the forces that led to the formation of this, was probably the production of Bowning Hill; but to enter into arguments to prove this would at present be a digression. All the strata are well defined except where severe plications have taken place.

To estimate the thickness of the whole system with any degree of exactness is at present not possible.

*Sections.*—Starting from the junction of Limestone and Barber's Creeks on the east, and proceeding nearly west to where the G. S. Road crosses the porphyry ridge on the western side of Bowning township, we obtain a section of the eastern division, or what may more properly be termed a double section; for, as stated already, this embraces a synclinal basin; and as one half of the basin differs slightly from the other I shall give an ideal section of each. The calculations as to thickness must be accepted as rough approximations only.

Commencing with the eastern section, a bed of coralline limestone advancing a little beyond our eastern boundary, first claims attention; this is found to rest on a stratum of micaceous grit, just beyond which the porphyry is exposed.

This limestone alone would afford matter for several papers. Probably not another place can be found in the colony so fraught with interest to the palæontologist and geologist. What an accumulation of ancient marine life is here displayed before our eyes! And how admirably preserved! Everywhere corals of various kinds present themselves, and commingling with them are numerous molluscs, *Euomphalus*, *Orthoceras*, *Pentamerus*, *Atrypa*, *Trochus*, and other genera being well represented. But to revert to the stratigraphical description of the bed. Throughout it has a stratified aspect; and at this point seems to be divided into two parts by a bluish micaceous rock. The lower division lies in thin strata separated from each other by thin layers of mudstone, thus giving evidence of periodical invasions of sediment into a clear sea. Distributed through the mudstone are calcareous nodules frequently containing

good fossils. The limestone is of a nodular character. This feature may have been caused by the presence of fine non-calcareous silt, which filled the spaces between the corals, and prevented their cohesion. This zone is rich in brachiopods and gasteropods. Of crustaceans I have obtained fragments of two trilobites, *Cheirurus*, sp., and *Cromus Beaumonti*. Among the brachiopods are the familiar Upper Silurian species *Atrypa reticularis*, *Pentamerus oblongus*; also, remarkable above others, is a deeply corrugated *Pentamerus* of triangular shape, that I have not yet identified, and which appears to be typical of this zone. The dip is from 30° to 40°, and its direction S. of W. The whole thickness may be estimated at 125 ft.

The upper portion of the bed is thicker and more compact. During its growth the invasions of silt had ceased, and corals and molluscs increased without hindrance except for the antagonism that may have prevailed among the different forms of life. The characteristic fossil, not coralline, is the large *Euomphalus Clarkei*. A very large *Pentamerus* also occurs. The dip is less than in the lower division and ranges from 15° to 20°. The upper division has a thickness of about 200 feet, so that the total thickness of the bed, therefore, may be fixed at 300 feet. Further south, however, at the Humewood beds of Mr. Jenkins's paper, it attains greater thickness. It may not be out of place to remark here that the general strike of the bed agrees well with the trend of our present coast-line. From this fact the obvious conclusion to be drawn is that our ancient coast-line had a similar trend.

Passing westward we advance to the next bed. Here we have presented the evidence of a great and sudden change in the ancient physical features. The clear sea became densely charged with fine sediment, which established the beginning of the end of the coral reef just referred to.

This bed not only introduces a great change in the character of the rocks, but a sweeping change of fauna. From this upward most of the large molluscs disappear to be seen no more throughout the series. Corals, encrinite stems, and some brachiopods are found in the lower part of the bed.

The later portion exhibits few fossils except bryozoan-like markings. Numerous cavities occur, and these were perhaps at one time occupied by corals. The composition is shaly, and its thickness 20 to 30 feet.

Next in order comes a bed of slightly hardened greyish shale, 40 to 50 feet thick at the point where I have made the section. In other places it reaches double of that thickness. This may be designated the 'lower trilobite zone,' for it is here that this order first appears as a distinguishing feature. In its eastern out-crop representatives of the following genera occur :—*Acidaspis*, *Cromus* (*Beaumonti*), *Encrinurus* (*punctatus*), *Calymene*, and *Sphaerexochus*. From the western outcrop, in addition to the above genera, it has yielded *Harpes*, *Bronteus*, *Cheirurus*, *Stauropcephalus*, *Proetus*, and others. The mollusca are represented, with few exceptions, by brachiopods of small size. Prints of hydrozoa are plentiful ; and occasionally the remains of a seaweed may be found. One of the most noteworthy things in connection with this bed is the sudden appearance of so many trilobites, and particularly those belonging to the genus *Acidaspis*, which in this case follows, instead of precedes, such genera as *Encrinurus*, *Cheirurus*, and *Cromus*. This bed came to an end by the cessation of sedimentary deposits, and a comparatively clear sea supervened for a short period, and admitted of the formation of a thin bed of impure limestone apparently not more than 10 feet thick. This is the 'Phacops Bed' of Mr. Charles Jenkins, (*vide* his paper on the Geology of Yass Plains). It is worthy of note that below these *Calceola sandalina* occurs ; also a small coral resembling *Petraia bina*. The whole bed largely consists of trilobite remains arranged in layers. The sea must have literally swarmed with them. But notwithstanding their number, to obtain a perfect specimen of any species is a rarity. Among the genera that can be distinguished are *Phacops*, *Acidaspis*, and one resembling *Angelina*. The largest species has, from the inspection of a fragment only, been pronounced to be *Phacops longicaudatus*. With Mr. Jenkins I consider that it bears a strong likeness to some forms of *Dalmania*.

Associated with these trilobites are the following:—A coral which I take to be *Petraia corniculum*, *Orthis testudinaria* (?), *Leptaena*, a large *Pleurotomaria*, *Platyceras*, sp., *Cyclonema*, *Strophomena*, an *Orthoceras* having a close affinity to *O. cereesiense*, and *Orthis biloba*. Superimposed on this bed is an immense one of shale with intercalated thin bands of flagstone. Its thickness cannot be less than 1,300 ft. Towards the completion of the bed the bands of flagstone and grit become more numerous and thicker. Throughout this vast deposit fossils are either rare or altogether absent. In the sandstone at the top I have obtained the prints of shells like *Orthis* and *Atrypa*. The absence of fossils from these shales would appear to have resulted from an absence of life over the area they occupied at the time of their formation, following upon the introduction of conditions unfavorable to organisms. The shales themselves are of a nature well-fitted for the preservation of organisms, had they been present.

From this bed we reach a series of beds that mark alternate periods of marine disturbance and inactivity. These are most likely sequences of considerable upheavals and subsidences of the then sea-bottom.

The first of these beds is one of conglomerate 20 feet thick. The matrix is shale or mudstone; some of the fragments are corals and pieces of limestone showing markings of *Pentamerus* and other shells. Then come 40 feet of soft shale followed by 25 feet of conglomerate rich in fragments of encrinital limestone. On this lie about 100 feet of sandstone of a flaggy character. Then follow about 250 feet of shale containing numerous water-worn stones, in parts almost a conglomerate. Near the top of the bed are many thin bands of flagstone. Next is a bed of laminated shale with bands of flagstone, 150 feet thick. On this rests a coarse conglomerate 50 feet thick. Enclosed are boulders of fossiliferous limestone. Succeeding this is a number of thin strata of shale and sandstone alternately, whose united thickness may be about 50 feet; and then is reached the latest deposit. This is a bed of coarse conglomerate that cannot have a thickness less



than 300 feet. It bears a very sea-shore aspect, and marks the close of the series. It has yielded a number of corals and some molluscs, all probably derived from the destruction of older beds. Among the latter are *Rhynchonella*, *Orthis*, and a *Megalodon*.

This completes a section of the eastern half of what may be termed the Bowning Synclinal Basin.

The western half differs very little from the eastern except that, instead of the limestone, at the base occurs a bed of coarse silicious grit, and there is some alteration of some of the lower strata to sinter and quartzite, and that, after the great bed of shale, the succeeding beds are fossiliferous to near the close of the series, including a third zone of trilobites.

Passing now to the western division. Resting against the porphyry are some altered rocks, and beyond these a bed of shale in some parts merging into impure limestone. It is rich in fossils, but they have suffered much decomposition and contortion. *Avicula*, *Pentamerus*, and some gasteropods are noticeable. The trilobites *Cromus Beaumonti*, and *Encrinurus punctatus* are also yielded. The thickness of the bed appears to be from 400 to 500 ft. Adjoining this bed on the line of section, that is along the G. S. Road, the rocks are hidden for some distance; but on the Binalong Road a mile further north the succeeding rocks are altered shales and jasper. From the shale I have obtained minute specimens of brachiopods and gasteropods. From this point to Flinter's Gap (locally known as Carroll's Gap), the western boundary of the parish, the rocks are all of altered character, as far as can be judged from the outcrops. They consist of variously coloured cherts and porphyroids of a jointy nature. Some bear indications of once having been fossiliferous. Their thickness is from 2,000 to 3,000 ft. I estimate the total thickness of this section at not less than 3,000 ft. The distance along this section is three miles nearly, which with the eastern portion gives a total sectional length of eight miles. The western section is doubtless in a large measure a repetition of the eastern one; but the rocks have been subjected to greater change. North and south of the sectional line the rocks appear in places less altered.

West of this formation come what have been termed by Mr. Jenkins the 'Murrumbidgee Beds,' which have been so designated because a good section of them is visible at Cave Flat on the Murrumbidgee; but in my opinion the name 'Coodradigbee River Beds' would be more appropriate; for nearly the whole course of this river passes along these beds in the direction of their strike. These beds are of interest because of their extent, and the likelihood that they are of Devonian age. Indeed the discovery by Mr. Ratte of the Australian Museum, of a portion of an *Asterolepis*, and certain Ammonites and Nautili of Devonian character in collections obtained from them, together with the fact pointed out by Mr. Jenkins in his 'Geology of Yass Plains', that most of the fossils recognised as Devonian types by De Koninck, and represented as belonging to the Yass beds, really belong to the beds in question, make their Devonian identity almost certain. Their occurrence can be traced from Boorowa on the north, southward through Binalong, Mylora, Bookham, Cave Flat, and along the course of Coodradigbee River (Little River, locally), for upwards of seventy miles.

*Palaeontological features.*—Owing to the difficulty of getting palaeontological specimens identified in the colony, I am not, in the present paper, able to give this branch the fulness of treatment its importance requires; but I hope shortly to be in a position to give a complete list of the fossils which occur in the Bowning series. At present my remarks will be confined to the genera, and a few species that have already been identified by Professor De Koninck through the instrumentality of the late Rev. W. B. Clarke, F.R.S., or whose identification is rendered easy by their wide distribution.

Up to the present no signs of terrestrial remains have been discovered, and the only vegetable remains yet yielded are prints of seaweed.

A distinctive feature of the Bowning beds, especially the Bowning side of the eastern division, is the number and beauty of the remains of hydrozoa and of polyzoa, among which may be

mentioned a sertularian, *Fenestella*, *Glaucanome*, and others. These are chiefly confined to the lower strata, associated with trilobites of the lower zone; and some of them bear a close affinity to Devonian types. Crinoids are plentiful.

The mollusca supply representatives of *Orthis* (*socialis* and *biloba* being among the species), *Atrypa* (*marginalis* and *reticularis*), *Terebratula*, *Pentamerus* (*oblongus* and *galeatus*), *Retzia*, *Pterinea* (*pumila*), *Spirifer* (*asper* and *crispus*), *Rotella*, *Patella*, *Trochus* (*bilix*), *Bellerophon*, *Euomphalus*, *Pleurotomaria*, *Ctenodonta*, *Leptaena*, *Meristella*, *Lingula*, *Rhynchonella*, *Discina*, *Orthoceras*, and *Megalodon* (one species). Among the Spirifers is one seemingly identical with a species obtained from the carboniferous rocks at Jamberoo.

Most worthy of special attention is the occurrence of *Orthis biloba*, *O. socialis*, *Pentamerus oblongus*, *P. galeatus*, *Spirifer asper*, *S. crispus*, *Atrypa reticularis*, *A. marginalis*, *Pterinea pumila*, *Platyceras angulatum* (?), and *Orthoceras cereesiense* Hicks, all typical of the Silurian age. A few of the many corals are *Favosites gothlandica*, *F. aspera*, *Heliolites interstincta*, *Receptaculites Clarkei*, *Petraia bina*, *Ptychophyllum*, *Zaphrentis*.

The Bowring series has peculiar interest by reason of the number of genera and species of trilobites it has yielded. My researches have brought to light 14 genera representing 30 species. They include *Encrinurus punctatus*, *Cromus Beaumonti*, *Bronteus Partschii*, *Calymene* (4 sp.), *Sphaerexochus mirus*, *Harpes*, *Phacops* (3), *Cheirurus*, *Lichas*, *Asaphus*, *Proetus*, and *Acidaspis*. Mr. Ratte (ante pp. 1066-1069) has identified several of these. Of other crustacean forms I obtained specimens of what appear to be fragments of a species of *Pterygotus* and of *Stylonurus*.

Of vertebrate remains no certain indications have been met with.

*Geological Age.*—Reviewing the general character of the fossils, especially those of the trilobite order, among which the genus *Acidaspis* stands out prominently, I have little hesitation in

referring the age of the Bowning Beds to the Upper Silurian System. The great development of shale rocks strengthens this conclusion.

*Minerals.*—Copper, iron, and lead occur in many places. Copper and lead ores are found in several parts of Limestone Creek; and small veins of galena are met with in Bowning Creek. A little gold has been obtained from some of the creeks which empty into the Limestone Creek.

*Surface Accumulations.*—The alluvial flats along the course of the Bowning and Limestone Creeks are formed of rich black soils. On some of the hills large accumulations of water-worn stones are noticeable. These have resulted from the disintegration of the conglomerates. Small agates are plentifully distributed among them. The decomposition of the unfossiliferous soft shales *in situ* has formed considerable beds of clay, while that of the fossiliferous shales has formed very fertile loamy soils. Some of these shales may be found to be of economic value as fertilizers.

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PLATE XXI.

IDEAL SECTION OF BOWNING SYNCLINAL BASIN.

(The data for the completion of the eastern portion of the section were obtained from the exposure of the strata in the Sharpening Stone Creek.)